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Citizens' views on various forms of energy and their contribution to the environment

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A B S T R A C T

In recent years, a shift has been observed in several countries towards the exploitation of RES for socio-economic and environmental purposes. Wind energy is a form of renewable energy resources (RES) which offers many advantages, particularly for countries such as Greece, which has a very promising wind potential. In addition, studies of citizens' views on the development of wind energy in Greece have been gaining particular attention due to recent decisions regarding the energy policy of Greece. More specifically, since August 2012, the examination of new applications for photovoltaic parks has been suspended, and only applications for wind parks are now being reviewed.

The present research was conducted on the island of Andros, where a wind park has been in operation since 1992, with a total annual capacity of 4740 MW. The data collection was carried out in 2010 using a structured questionnaire, and involved the citizens as electrical energy consumers. In particular, their views were studied regarding their satisfaction with the quality and availability of electricity on the island, and the installation of wind turbines. They were then asked to evaluate how environmentally–friendly various forms of energy are, as well as the effects from the use of RES.

The research results indicate that the citizens are positively disposed towards the installation of wind parks in their area, particularly in the northern part of the island, where a wind park is already installed. After evaluating the various forms of energy, they consider solar, wind and hydroelectric energy to be the most environmentally-friendly energy forms. The use of renewable energy sources will have an impact in reducing carbon dioxide emissions, on the energy supply, lower the relevant costs and contribute to local development with through the creation of new employment opportunities.

Contents

1. Introduction

Fossil fuels, such as oil, coal and natural gas, play a major role in the global demand for energy today. However, the geographical

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distribution of fossil resources, their probable depletion and the significant effects on the increase of carbon dioxide render imperative the search for alternative energy sources, both on a national and international level [1,2].

The development of RES has been shown to follow an upward trend. The technical aspects of biomass, and in particular solar photovoltaic (PV) systems, still require further improvements, since their implementation depends to a large extent on subsidies and their impact on the environment and humans. Wind energy has significantly improved its technical features and has been successfully used in Germany, Denmark and Spain. It is not developing at a satisfactory pace however in Sweden, Greece, Italy and France, and consequently it has proven impossible for these countries to reach their desired objectives [1].

Wind energy constitutes a sustainable, environmentally-mild energy source, which could contribute to the energy autonomy of the islands [3]. Nevertheless, since the mid-1990s, the siting of wind parks has come up against protests, which even today are increasing and spreading. Nowadays, any plans for a wind park are met with disagreements. A large number of studies have examined these citizens' views [1,3–6], thus creating the preconditions for a reduced number of reactions, whatever their origin. Nevertheless, as the development of wind energy installations is delayed due to social reactions, the scientific interest in citizens' views is increasing [1].

Technological developments have allowed wind energy to become a major energy source, which can question the use of fossil fuel and be considered as the main solution for achieving the goals set [7]. It is a source of electrical energy with a minimal environmental impact [8] and its use is therefore expected to significantly increase in the future [9].

The best way to facilitate the development of wind parks is through the creation of an institutional framework that will involve the participation of stakeholders in the decision-making processes. The need for collaboration has been largely perceived by the general public, not only in the case of wind energy but also as regards other RES, in order to examine the process of project implementation. Lack of communication can only lead to problems both with the public and with local authorities, which often cause delays or even the cancellation of investment plans. What happens in most cases, as regards the competent bodies, is that they seek public participation only after a project has been announced [10,11]. Furthermore, the relevant discussions may often simply be a pretext or the timing may be wrong.

Many studies indicate a positive attitude from the majority of the population in Europe and the US regarding wind energy, and the expansion of wind power [1,3,9,12–15]. However, other studies express the negative views of residents [16,17].

During the last decade in particular, the installation of wind turbines on land for the production of electricity has significantly increased. Given the fact that wind energy is a relatively small-scale energy source, the production of major amounts of electrical energy requires the construction of numerous wind parks in different areas. Due to the large number of wind turbines, it is possible that such installations will be visible to a large number of people [7]. Their main impact is the distortion of the landscape, noise and their effect on the avifauna [18]. These considerations have been making it more and more difficult to find suitable locations that are considered acceptable by the public.

The attitude of the public towards wind energy has been found to be related to characteristics such as age (negatively), gender, experience of offshore wind parks, and whether they use the local beaches. It is interesting to note that the views of the respondents who can or cannot see the wind turbines from their home do not differ greatly. It is also observed that the respondents would generally prefer offshore to inland wind parks [16]. In addition, there is a positive outlook from studies of citizens' views as regards the wind energy installations that are visible from their homes or summer houses [9]. Many people claim that the future of wind energy lies in offshore installations, which largely address the problem of noise pollution; however, the aesthetic impact still remains an issue [6,7,16,19]. The main group affected are beach users, who may express a variety of opinions. Wind parks, which by nature are located along the coast, could affect the attitude of tourists who visit a beach or area [20,21]. Furthermore, the installation of wind turbines on land still continues to be the most feasible solution, due to the low installation and maintenance costs involved [16].

Another aspect of public acceptance is the issue of ownership, which directly affects the psychology of the residents. After researching two areas in Scotland, a positive stand towards wind energy was observed. In the one region however, where the wind turbines belonged to the local community and the relevant location had been named, the public attitude was more positive compared to the other area where such a relation had not been established. This fact supports the view that a change in the developmental model that would involve the local community could have a positive effect on the views of the local population [22].

Citizens' preferences for various forms of energy show a strong opposition against nuclear energy. On the contrary, almost two-thirds of the sample supported investment in RES. From an analysis of the data, it seems that being aware of the problem of climate change is a common factor that explains the public's attitude, both as regards nuclear energy and RES. However, the high levels of concern regarding the environment have differentiated the supporters of RES from those who support nuclear energy. The latter seem to be people with knowledge of the problem of climate change, who are involved in environmental issues, but are less concerned about the environment and feel optimistic about its future. On the other hand, the opposers of nuclear energy were found to be concerned about the environment and feel pessimistic about its future [23].

The problem of identifying alternative forms of energy becomes even greater in the case of island regions, whose connection to the national grid is often either impossible or very problematic in its operation. The problem of energy efficiency in island regions has two aspects. On the one hand, most islands present a major population increase during the summer season [4], thus necessitating an uninterrupted, reliable electricity supply. On the other hand, the installation of alternative energy forms must not cause any distortion to the landscape, which may impact on the development of tourism. The geographical location of several islands is often also problematic, hindering investments in wind energy [24]. The main issue lies in the high investment costs required which prevent new investments from being made [25].

Island regions are in a privileged position in relation to other parts of continental Greece, as regards the abundance of renewable energy sources (RES), such as wind, sun, etc. The valorisation of these natural energy forms provides significant advantages, both for the tourist destinations per se and for the tourism enterprises active in these areas, by contributing to energy efficiency, supply security, an energy system better adapted to the demand model, the development of financially viable solutions for energy provision, the decentralisation of the energy production system etc. [4,26].

As regards the islands of Greece, there is a constant and rapid increase in electricity consumption, which in some cases exceeds 10% on an annual basis. The increase in the demand for electricity, especially during the summer months, has been addressed to date through the installation of additional thermal units for electricity generation, in order to avoid any major failures of the electricity grid, which requires particular support during the tourist season. The absence of an integrated plan for dealing with the electricity supply problem results in minimally reliable solutions. The significant increase in the prices of imported oil should also be noted, as well as the grave environmental impact from its use. Unfortunately, the

current condition of the local electricity grids minimises the contribution of RES to electricity generation [4].

The aim of the present paper is to examine the views of the citizens of Andros island as regards wind and other forms of energy, and the impact from the use of renewable energy sources. The results of the study will significantly contribute to the relevant literature, since wind parks have existed in this area since 1992. This particular model of developing existing parks could be used in order to minimise the reactions of citizens seen in other areas with similar characteristics.

2. The EU policy framework for renewable energy sources

The rapid promotion of RES is one of the fundamental axes of EU policy, within the framework of its efforts to address climate change and its potentially disastrous consequences. Inextricably linked to the policies that dictate a drastic limitation of carbon dioxide emissions and energy-saving measures, the European policy on RES has set a binding objective, according to which 20% of the total energy consumed in the EU by 2020 must come from RES. The pre-set policy framework for dealing with climate change, an integral part of which is the rapid promotion of RES penetration, is only the first step in the effort to shift towards an economy with low greenhouse gas emissions. This effort will not be completed in 2020, but according to the road map for the climate, preparations are already being made for the period after 2020, when the goals for a reduction in emissions will be even higher. Such a development will provide a huge impetus to an unhindered transformation of the energy system, through the exploitation of low or zero emission technologies, as is the case with the majority of RES [27].

On a global level, the EU must take advantage of its position as the second largest energy market and a global leader, in the demand, management and promotion of renewable energy sources. The EU should strengthen its relations with its energy partners, aiming to promote and diversify the relevant sources and routes, strengthen partnerships and collaboration with a focus on reducing greenhouse gas emissions, and increase renewable energy sources and energy efficiency [28].

In 2011, 27 new wind parks were installed in the EU, with a total capacity of 9616 MW, thus increasing in total the installed wind capacity to 93,957 MW, which is sufficient to cover 6.3% of the EU electricity demand. In top position comes Germany, with a total installed wind capacity at the end of 2011 amounting to 29,060 MW, followed by Spain with 21,674 MW. In Greece, the total installed wind capacity is equal to 1629 MW [29].

3. Wind energy in Greece

An accelerated integration of RES is considered to be imperative for Greece in order to fulfil its goals for 2020, which state that 20% of its gross national energy consumption and 40% of its gross national electricity consumption must be covered by RES. The availability of suitable locations for installing such systems is often questioned, since in many areas with a high RES potential and the necessary infrastructure, it is the local community which creates additional obstacles [30].

The exploitation of wind energy in Greece presents the following advantages: (a) the country, and mainly the island complexes of the Aegean, offers a very high wind potential, (b) their high seismic properties create risks for thermo-electric and mainly nuclear installations, and thus the construction of nuclear units is regarded as problematic and costly, (c) the development of Greek manufacturing activities with products of a high domestic added value (e.g. co-production of wind turbines in Greece), (d) the exploitation of the scientific potential active in electromechanical projects, (e) opportunities for decentralised development through autonomous energy production systems, a fact that could greatly assist the economic activities of local communities, (f) decentralised electricity production limits losses and transportation costs, thus contributing to the support of local networks [31].

Despite the comparative advantages that wind energy presents in Greece, its development is hindered by several issues. An increase of the installed capacity has been noted in recent years, but is considered minimal given the great wind potential of our country. Until 2001, the legislative framework and monopoly model of the economy, as regards electricity production, were the main causes for the limited installation of RES. Following the legislative changes in the field of RES, and the liberalisation of the energy market, the situation has considerably improved. However, it is obvious that there is insufficient interest in investments. The main reasons for this delay are: the long-winded and complicated licencing process, the inability of the grid to support additional installed capacity, the residents' reactions particularly regarding issues of visual disturbance, and a lack of spatial planning. The problem of social reaction, when related to the visual disturbance caused by wind turbines, is always difficult to address, in the sense that it is quite a subjective matter to note whether a person is upset or not by the sight of a wind turbine. The issue of spatial planning is determined by the special spatial planning framework for RES, which has been implemented since December 2008, and has been incorporated in the licencing process for wind parks.

A major factor that favours further growth in wind energy is the latest decisions taken by the Ministry of the Environment, Energy and Climate Change. More specifically, the submission of new requests and the review of pending PV requests (household requests are exempt, and those subject to the fast track process) has been suspended, with the argument that there are already numerous mature projects, whose implementation will lead to achieving the goals for 2020 (http://www.ypeka.gr). However, the suspension of the licencing process does not apply to wind parks and RAE (Regulatory Authority for Energy) continues to accept applications for wind parks.

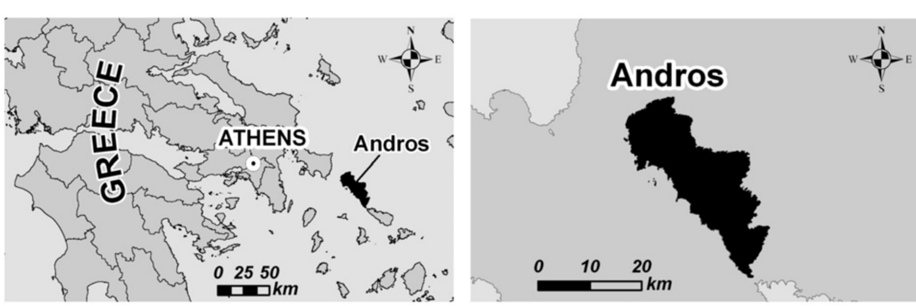

Fig. 1. Island of Andros.

4. Research methodology

4.1. Research area

Andros is the northernmost island of the Cyclades and second in size to the island of Naxos. From an administrative perspective, it is a province consisting of three municipalities: Andros, Korthi and Ydroussa. The island covers an area of 374 km^2, with a maximum length of 39.8 km, a maximum width of 16.7 km, a 177 km coastline and an oblong shape extending from N–NW to S–SE (Fig. 1). According to the census of 2011, the population has been estimated as being 9170 people.

The main production sectors in Andros involve agricultural activities, shipping and tourism, which has experienced development during the last 25 years. As regards its agricultural production, the most developed crops are lemon trees, mulberries, olives, and citrus fruit, and great emphasis is also being given to the cultivation of vineyards, potatoes and grains. The economic activities of the island in the secondary sector are generally in line with the overall pattern followed by the Cyclades prefecture. The sectors presenting the highest development are constructions and the food and beverage industry. Due to the island's proximity to Athens and the increased demand for summer houses, there has been a boost in construction work. Generally speaking, entrepreneurship in Andros is not particularly developed, as is the case with the whole of the Cyclades prefecture. Mykonos is the island with the highest level of business activity, with 4.5 residents per business, whereas in Andros the relevant rate is only 10.95. Livestock production is also quite developed, to the point that its products are able to cover the local consumers' demands [32].

As regards electricity provision, the island is connected to the national grid via an underwater cable, which joins it with Aliveri, Evia. The lifespan of these cables is 20 years, and failures often occur. The connection continues via Andros as far as Tinos. At the port of Chora in Andros, a PPC (Public Power Corporation) diesel-fuelled power plant is installed, with a programmed capacity of 15 MW. This unit operates in the case of failure or overloading of the grid, and also for scheduled maintenance work. At Stavropeda, there is a PPC substation, where the energy is transformed from 150 KV to 20 KV. Connected in parallel to the national grid is also the PPC wind park at Kalivari, which is situated at the northernmost point of the island and has been in operation since 1992. The wind park consists of seven wind turbines with a capacity of 225 KW each, i.e. with a total capacity of 1575 KW. As regards their technical characteristics, they are Vestas V-27, have a height of 36–38 m, with three 13-m long blades, and a diameter of 26 m [33].

They are linearly arranged with an intermediate distance of 100 m and cover a total area of 30 ha. The production level of the wind park for 2000 was 4504 MW and corresponded to 12% of the total energy produced by the autonomous diesel-fuelled thermoelectric station, when in operation. Today, it contributes approximately 4740 MW to the island's grid per year. The advantages from this energy form are that the turbines operate throughout the year, due to the strong winds blowing in the region, along with the fact that they operate at a low voltage. The electricity produced is 380 V, while 20,000 V is the mean voltage of the distribution line grids. Failures to the wind turbines are caused by lightning, which may destroy the blades, as has occurred in the past [33].

4.2. Sampling method

The sampling method used was simple random sampling, due to its simplicity and the fact that it requires the least possible knowledge of the population compared to any other method [34,35].

In order to estimate the size of the sample, a pre-sampling was conducted on a sample size of 50 persons. Thus, the variance or standard deviation was estimated for each quantitative variable, and the proportion for each qualitative variable. The size of the sample was estimated according to the formulae of simple random sampling with replacement [35,36]. The finite population correction can be ignored since the sample size n is large compared to the population size N ($n/N=50/10{,}009=0.00499$ i.e. approximately 0.5%) [37].

In order to estimate the sample size required to estimate the mean, we use the formula

$$n=\frac{t^2\cdot s_y^2}{e^2}=\frac{1.96^2\cdot 2.835^2}{0.29}=367.15\cong 368 \tag{1}$$

where s_y^2 is the estimation of the population variance from the sample data; t is the value of the Student distribution for probability $(1-\alpha)=95\%$ and $n-1$ degrees of freedom. Since the size of the conducted presampling is large (over 50), the value t is obtained from the probability tables of the normal distribution for the desired probability. In practice, for a 95% probability, the value is 1.96 [36]; e is the maximum acceptable difference between the sample mean and the unknown population mean. We accept that it is 0.29.

Thus, the definition of the sample size for the variables referred to in proportions is provided by the formula

$$n=\frac{t^2\cdot \overline{p}\cdot(1-\overline{p})}{e^2}=\frac{1.96^2\cdot 0.50\cdot(1-0.50)}{0.05^2}=384.16\cong 385 \tag{2}$$

where p is the proportion estimation; e is the maximum acceptable difference between the sample mean and the unknown population mean. We accept that in the case of proportions it is 0.05, i.e. 5%. t is the value of the Student distribution for probability $(1-\alpha)=95\%$ and $n-1$ degrees of freedom.

The use of a questionnaire is not limited to estimating only one but more population variables. Thus, we need to estimate the sample size for each variable. The variable that provided us with the largest sample size, in order to estimate the arithmetic mean (quantitative variables), was "evaluation of RES—biofuels". Respectively, in order to estimate the population proportion (qualitative variables), the variable which gave us the largest sample size was "acceptance of the PPC pricing policy", i.e. increasing the kWh price depending on the consumption level.

If the estimated sample sizes are similar and the size of all lies within the financial means of the sampling, then the sample size selected is the largest one. In this way, the variable with the highest variance is estimated with the desired accuracy, and the rest with a higher accuracy than originally determined [36]. Thus, the sample size was set at 385 people.

The citizens in the sample were then identified using random numbers we obtained from random number tables. Face-to-face interviews were carried out. If the citizens were absent or refused, two more efforts were made to record their opinion. Where this proved impossible, we followed the same process in order to select new sampling units. The data collection took place in 2010 and the SPSS statistical package was used for the analysis.

4.3. The research questionnaire—statistical processing

The specific research was conducted using a structured questionnaire and face-to-face interviews. The latter method is one of the best ways to collect statistical data and is broadly used for sampling research [38–42].

In order to structure the questionnaire, the relevant literature was taken into account, regarding the impact of RES on the local economy and society [1,3–5,43–50]. The research questionnaire is

provided in the annex and only part of it was used in the present research.

The primary data collected and presented in this study are related to the socio-demographic characteristics of the respondents and their views and attitudes regarding: their satisfaction with the quality and availability of electricity on the island, the installation of wind turbines in their area, an evaluation of how environmentally-friendly various forms of energy are, and finally, the impact from the use of renewable energy sources.

Descriptive statistics were used for the data processing, which included the non-parametric Friedman test and factor analysis.

The Friedman test is used to compare the values of three or more correlated groups of variables. The distribution of the Friedman test is χ^2 distribution with (df) $df=k-1$ degrees of freedom, where k is the number of groups or samples. This test classifies the values of the variables for each subject separately and calculates the mean rank of the classification values for each variable [51,52].

Factor analysis is a multivariate statistical method which aims to examine the existence of common factors within a group of variables [53]. It attempts to interpret their structure rather than their variability [54]. Its objective is to reproduce the correlations among the variables to the highest degree possible, by using the smallest possible number of factors, and to arrive at a solution that is ‘‘typical’’ and easy to interpret [55]. More specifically, the principal components method was used, which is based on a spectral analysis of the variance matrix [54–59]. The criterion used regarding the significance of the principal components is the one proposed by Guttman and Kaiser [60,61], according to which, the limit for obtaining the recommended number of principal components is determined by the eigenvalues that are equal to or higher than one. The matrix rotation of the principal components was carried out using Kaiser's maximum variance rotation method [55,62]. Finally, we examine the factors that can interpret the correlations among the variables of our data and provide them with some interpretation (if possible) [58,63]. The variables that ‘‘belong’’ to each factor are those for which the loading is higher than 0.5 for that factor, in the table presenting the factor loadings, following rotation [61].

5. Results and discussion

As regards the socio-demographic characteristics, there is a predominance of women (57.7%). The majority is in the age group 18–40 years (52.6%) and has completed tertiary education, either at University or at a Technological Educational Institute (TEI). Most of them are self-employed (27.3%) or civil servants (18.6%). About one in three do not wish to state their income; of the rest, 18.7% have an income in the 10,001–20,000 euro range (Table 1).

As regards the quality and availability of electricity on the island of Andros, the citizens are relatively satisfied (Table 2). It is therefore accepted that the existing electricity supply system marginally satisfies the citizens' needs, which means there are great possibilities for improvement. Further investments in RES, and in wind energy in particular, will contribute towards the energy supply of the island.

In general, the citizens are interested in the installation of wind turbines on their island. Most of them adopt the view that the wind turbines should be installed in the northern part of the island, since 83.7% either agree or fully agree, while 16.3% of the citizens of Andros island either disagree or totally disagree. They also positively view the siting of wind turbines offshore, or at a point where they will have visual contact with them from their homes (Table 3).

There is broader acceptance for the inland installation of new wind parks, and in particular in the northern part of the island, where a wind park has been installed since 1992. There is also broad acceptance of the possibility of offshore installations, and also of inland installations that are visible from the locals' homes. This preference stated by the local population offers many solutions to the bodies responsible for the siting of wind parks. The installation of wind parks on land is a favourable option, due to the lower costs involved compared to offshore installations. On the other hand, offshore wind parks are preferable when we want to avoid disturbing the citizens, mainly by the noise and aesthetic impact of the parks [6,7,16,19]. Offshore wind parks offer the above-mentioned advantages but may have a negative effect on tourism in the long run. The citizens of Andros have perceived this parameter and for this reason prefer an expansion of the wind parks in the areas already tested, which have not affected the tourism demand.

The next question examined how environmentally–friendly each energy form is considered to be on a scale of 1–10 (where 1 is the lowest impact on the environment and 10 is the highest impact on the environment). The following energy forms were examined: lignite combustion (Q1_1), coal combustion (Q1_2), oil combustion (Q1_3), natural gas combustion (Q1_4), hydroelectric

Table 2
Citizens' views on their satisfaction with the quality and availability of electricity on their island (%).

	Very good	Good	Average	Bad	Very bad	Total
Quality and availability of electricity	4.2	33.8	42.6	15.3	4.2	100.0

Table 1
Socio-demographic profile of the sample (%).

1. Gender					
Male	Female				
57.7	42.3				
2. Age					
18–30	31–40	41–50	> 50		
29.8	22.8	19.6	27.7		
3. Educational level					
None—some grades of primary school	Primary school	Lower secondary school	Technical school	Upper secondary school	University/TEI
1.3	7.3	6.2	9.4	31.5	44.3
4. Profession					
Unemployed/student	Farmer–fisherman–pensioner	Housework	Private employee	Civil servant	Self-employed
14.1	17.1	6.5	16.4	18.6	27.3
5. Annual income (euro)					
< 5000	5000–10,000	10,001–20,000	20,001–30,000	> 30,000	No answer
13.0	13.2	18.7	13.5	6.5	35.1

Table 3
Citizens' views about the installation of wind turbines at various parts of the island.

	Fully agree	Agree	Disagree	Totally disagree	Total
In the north of the island	35.7	48.0	10.7	5.6	100.0
At a point that will be visually perceptible from their home	18.2	49.1	21.1	11.6	100.0
Offshore	29.4	38.0	23.0	11.6	100.0

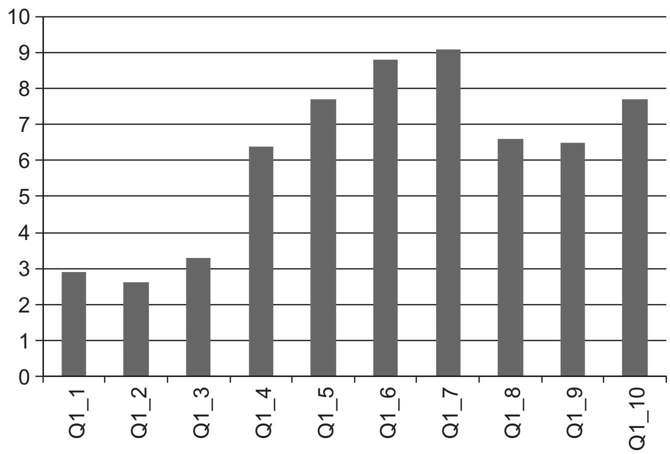

Fig. 2. Evaluation of different energy forms regarding their environmentally–friendly aspect (means).

Table 4
The application of the Friedman test on how environmentally–friendly the various forms of energy are considered to be.

Energy forms	Mean Rank
Lignite combustion (Q1_1)	2.6610
Coal combustion (Q1_2)	2.4024
Oil combustion (Q1_3)	3.0616
Natural gas combustion (Q1_4)	5.3716
Hydroelectricity (Q1_5)	6.8356
Wind energy (Q1_6)	8.1182
Solar energy (Q1_7)	**8.4349**
Nuclear energy (Q1_8)	5.7021
Biofuels (Q1_9)	5.7003
Geothermal energy (Q1_10)	6.7123
$N=$ 292, $\chi^2=1427.145$, $df=9.000$, Asymp. Sig$=0.000$	

(Q1_5), wind energy (Q1_6), solar energy (Q1_7), nuclear energy (Q1_8), biofuels (Q1_9) and geothermal energy (Q1_10).

Regarding the extent to which the various forms of energy are environmentally–friendly, the citizens of Andros island consider that solar energy has the least environmental impact. In fact, the sun is used by a large number of residents to heat water, through the use of various domestic appliances. They therefore have direct knowledge of the fact that no problems are related to its use. They also consider wind, hydroelectric and geothermal energy to be environmentally–friendly (Fig. 2). Apart from the mean rank of classification, we further examined the citizens' views to see whether there is a statistical difference between them concerning the said question, and used the Friedman test for this purpose. The application showed that the most environmentally–friendly form of energy is solar energy with a mean rank of 8.4349 ($\chi^2=1427.145$, $df=9$, Asymp. $Sig=0.000$). It is worth noting that the next most environmentally–friendly energy form is considered to be wind energy with a mean rank of 8.1182 (Table 4). It is important to mention that although the citizens are directly aware of the drawbacks of wind energy, since wind parks have been installed on the island for many years, they nevertheless rate it very highly.

In order to examine the structure of the respondents' views regarding how environmentally–friendly the various energy forms are considered to be, principal component analysis (PCA) with varimax rotation of the factorial axes was applied to the citizens' answers regarding the multidisciplinary question Q1. The analysis highlighted three important factors or factorial axes that together explain 58.8% of the total variance.

Before we proceeded with the application of factor analysis, the necessary tests were carried out as regards the above-mentioned multidisciplinary variable. The Keiser–Meyer–Olkin index has a value of 0.755 regarding the environmentally–friendly aspect of the various energy forms. It is suggested that the KMO index should be higher than 0.80, however, values over 0.60 are also accepted [53]. Furthermore, Bartlett's sphericity test produced the following results ($\chi^2=697.823$, $df=45$, $p<0.001$), which means that the relevant correlation matrix presents a statistical significance from the unitary matrix. The communalities for each item were higher than 0.52, which indicates a good quality of regrouping of the initial data, based on the model of the two factorial axes. Furthermore, the sampling suitability measures (MSA) have high to very high values, which support the view that the factor analysis model is acceptable.

Table 5 presents the loadings, which are the partial correlation coefficients of the 10 variables, with each of the three factors that have emerged from the analysis. The higher the loading of a variable to a factor, the more that factor is responsible for the total variance of scores in the variable under study. The variables that "belong" to each factor are those whose loading (columns 1, 2 and 3) is higher (than the value 0.5) for the said factor [61].

More specifically, from the application of factor analysis as regards the various energy forms and to what extent they are environmentally–friendly, three factors emerged. The first factor, that comprises "fossil fuels", includes the variables "lignite combustion", "coal combustion" and "oil combustion". The second factor, that comprises "renewable energy sources", includes the variables "geothermal energy", "hydroelectric energy" and "biofuels". Finally, the third factor comprises "fossil fuels and renewable forms" and includes the variables "nuclear energy", "natural gas combustion", "solar energy" and "wind energy".

The citizens' attitudes were examined regarding the impact from the use of renewable energy sources. The potential effects from the use of renewable energy sources are: reduction of carbon dioxide emissions (Q2_1), improved energy independence and security (Q2_2), low operating cost (Q2_3), reduced losses during transport (Q2_4), new employment opportunities (Q2_5), non-controlled energy supply rate (Q2_6), high manufacturing cost (Q2_7), downgrading of areas, reduced land value (Q2_8), lack of transparency in installation licence provision (Q2_9) and the need for specialised staff (Q2_10).

The citizens of Andros island consider that the use of renewable energy sources will lead to positive results. More specifically, there will mainly be a reduction in carbon dioxide emissions and improved energy independence and security (Fig. 3). We can therefore agree on the fact that these are the main advantages stemming from the use of RES, for people who are not involved in relevant investments.

Next, in order to ascertain whether there is a statistical difference between the citizens' views and the effects from the use of renewable

energy sources, the Friedman test was applied. Its application showed that the main effect is a reduction in carbon dioxide emissions with a mean rank of 7.5641 (χ^2=398.153 df= 9.000 Asymp. Sig=0.000) (Table 6).

In order to examine the respondents' answers in relation to the effects from the use of renewable energy sources, principal component analysis (PCA) with varimax rotation of the factorial axes was applied to the answers of the citizens to the multi-disciplinary question Q2. The analysis highlighted three important factors that together explain 63.8% of the total variance.

The necessary tests were carried out on the above-mentioned multidisciplinary variable, before we proceeded with the application of the factor analysis. The Keiser–Meyer–Olkin index has a value of 0.773 regarding the effects from the use of renewable energy sources. Bartlett's sphericity test provided the following results (χ^2=917.312, df=35, $p<0.001$), a fact which signifies that the relevant correlation matrix presents a statistically significant difference from the unitary matrix. The communalities for each item were higher than 0.58. Furthermore, the sampling suitability measures (MSA) have high to very high values, which support the view that the factor analysis model is acceptable.

From the factor analysis used in order to identify the factors related to the effects from the use of renewable energy sources, three factors emerged (Table 7). The first factor comprises the "direct positive effects from the use of renewable energy sources" and includes the variables "new employment opportunities", "low operating costs", "reduction of losses during transport" and "need for specialised staff". The second factor comprises the "negative effects from the use of renewable energy sources" and includes the variables "downgrading of areas, reduced land value", "high manufacturing costs", "lack of transparency in installation licence provision" and "non-controlled energy supply rate". Finally, the third factor comprises the "indirect positive effects from the use of renewable energy sources" and includes the variables "reduced carbon dioxide emissions" and "improved energy independence and security". The above-mentioned impacts, as noted earlier, are also the most important, according to the citizens' views. Moreover, the variable "improved energy independence and security" also presents a high value in relation to the first factor (Table 7). Thus we can accept that this variable links the direct with the indirect positive effects from the use of renewable energy sources, i.e. the first factor with the third.

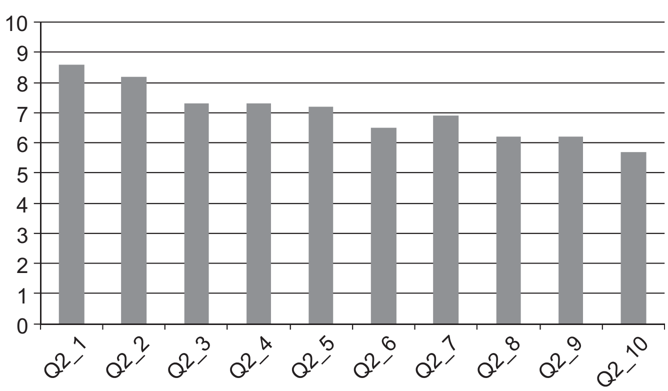

Fig. 3. Effects from the use of renewable energy sources.

6. Conclusions

The benefits of RES have been perceived in the island areas of Greece. In the case of Andros, the citizens realise that there are several options that could improve the quality and availability of electricity on their island.

The fact that there has been a wind park in Kalivari, at the northernmost point of the island, since 1992, seems to have positively affected the potential installation of new wind turbines on their island. In general, the familiarisation of citizens with wind energy has made them more willing to adopt this energy form. The greatest level of acceptance relates to their siting in the northern part of the island, followed by offshore installations and finally their siting in areas that are visible from the citizens' homes. It should be noted that no offshore wind park has been installed in Greece to date.

Nevertheless, the citizens consider that it is solar energy which has the least environmental impact, followed by wind, hydroelectric and geothermal energy. Even though there is no photovoltaic park on the island, the citizens have been largely familiarised with solar

Table 6
The application of the Friedman test to measure the effects from the use of renewable energy sources.

Effects from the use of renewable energy sources	Mean rank
Reduced carbon dioxide emissions (Q2_1)	**7.5641**
Improved energy independence and security (Q2_2)	6.9141
Low operating cost (Q2_3)	5.7688
Reduced losses during transport (Q2_4)	5.6656
New employment opportunities (Q2_5)	5.6500
Non-controlled energy supply rate (Q2_6)	4.8219
High manufacturing cost (Q2_7)	5.2391
Downgrading of areas, reduced land value (Q2_8)	4.6594
Lack of transparency in installation licence provision (Q2_9)	4.6344
Need for specialised staff (Q2_10)	4.0828
N= 320, χ^2=398.153, df=9.000, Asymp. Sig=0.000	

Table 5
The factor loadings of the data prior to and following rotation, for each of the various energy forms.

Variable	Factor loadings					
	Prior to rotation			Following rotation		
	1	2	3	1	2	3
Lignite combustion (Q1_1)	−0.6659	0.4154	0.2367	**0.8107**	−0.1212	0.0091
Coal combustion (Q1_2)	−0.6471	0.4637	0.0624	**0.7913**	0.0186	−0.1056
Oil combustion (Q1_3)	−0.6624	0.3098	0.0723	**0.7104**	−0.1029	−0.1575
Geothermal energy (Q1_10)	0.3957	0.4544	−0.4336	−0.1090	**0.7343**	−0.0020
Hydroelectricity (Q1_5)	0.4985	0.3283	−0.4054	−0.2594	**0.6728**	0.0275
Biofuels (Q1_9)	0.2117	0.6025	−0.1582	0.1773	**0.6072**	0.1810
Nuclear energy (Q1_8)	0.5488	−0.0594	0.6375	−0.3282	−0.1641	**0.7593**
Natural gas combustion (Q1_4)	0.1158	0.5207	0.4875	0.3290	0.1474	**0.6264**
Solar energy (Q1_7)	0.7989	0.2048	0.1712	−0.4495	0.3910	**0.5954**
Wind energy (Q1_6)	0.7301	0.1637	0.1507	−0.4264	0.3439	**0.5314**

Table 7
The factor loadings of the data prior to and following rotation, for each of the effects from the use of renewable energy sources.

Variable	Factor loadings					
	Prior to rotation			Following rotation		
	1	2	3	1	2	3
New employment opportunities	0.6750	−0.3191	0.3487	**0.8016**	−0.0181	0.1903
Low operating cost	0.7063	−0.3761	0.2250	**0.7649**	−0.0476	0.3219
Reduced losses during transport	0.7176	−0.2434	0.0706	**0.6373**	0.0868	0.4068
Need for specialised staff	0.4062	0.3520	0.6239	**0.5740**	0.4508	−0.3813
Downgrading of areas, reduced land value	0.2929	0.7170	−0.2192	−0.1407	**0.7860**	0.1021
High manufacturing cost	0.3712	0.6696	−0.2125	−0.0655	**0.7767**	0.1539
Lack of transparency in installation licence provision	0.3482	0.6641	0.1845	0.1654	**0.7355**	−0.1673
Non-controlled energy supply rate	0.5432	0.3112	−0.0854	0.2464	**0.5205**	0.2600
Reduced carbon dioxide emissions	0.6485	−0.2064	−0.5154	0.2131	0.1291	**0.8165**
Improved energy independence and security	0.7480	−0.2837	−0.3193	0.4300	0.0897	**0.7409**

energy for several decades, since they have autonomous solar water-heating systems in their homes (solar heaters). Also, we observe that the citizens link solar and wind energy to one factor, and hydro-electric and geothermal energy to another.

Their opinion is that the use of renewable energy sources will have a positive result in reducing carbon dioxide emissions and improving energy independence and security in their country. In fact, with the use of factor analysis, we see that the two above-mentioned variables comprise the factor named "indirect positive impact from the use of renewable energy sources", which indicates that the citizens realise that the use of renewable energy sources has more to offer the country as a whole (on a national level), rather than the local community.

In conclusion, the people of Andros consider investments in RES to be an acceptable solution regarding the energy supply of the island, that will also help to create new employment opportunities. They also consider that the installation of RES must safeguard environmental protection.

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Annex

Questionnaire

1) What's your opinion about the quality (voltage) and availability of electricity on your island?				
Very good	Good	Average	Bad	Very bad
2) What's your opinion about the cost of the electricity you pay for?				
Too expensive	Expensive	Neither expensive nor cheap	Cheap	Very cheap
3) Do you agree with the pricing policy followed by the Public Power Corporation (DEI), i.e. increasing the price per kWh depending on the consumption level?				
		Yes	No	
Does this policy make you reduce your consumption			Yes	No
4) What is the rate of increase you would be willing to pay in the price of electricity, in order for 20% of electricity to be produced by renewable energy sources?				
None	Less than 5 %	5–10%	11–20%	More than 20%
5) Do you use energy saving-ecological bulbs at home?				
	Always	Frequently	Rarely	Never
6) When you come out of a room at home, do you tend to switch off the lights?				
	Always	Frequently	Rarely	Never
7) When purchasing household appliances, are you influenced by the energy labels that provide information about the energy consumption levels of the appliances?				
Very much	A lot	Quite a lot	A little	Not at all
8) When you are not using your TV, is it				
On standby, ready to switch on with the remote			Switched off	
9) Do you have a solar thermal collector at home for hot water?				
			Yes	No
10) What type of air-conditioning unit do you have at home?				
Old technology	New ecological technology (inverter)		I do not have an A/C unit	
11) Do you agree with the application of the measure involving energy efficiency in buildings? Should a house have an energy efficiency certificate in order to be sold or rented?				

Yes   No   I do not know

12) Do you agree that it is necessary for us all to save energy?

I totally agree   I agree   I disagree   I totally disagree

13) Do you believe that the messages on saving electricity that are promoted through the Mass Media are:

Fully satisf.   Very satisf.   Satisfactory   Hardly satisf.   Not at all satisf.

Through special leaflets are:

Fully satisf.   Very satisf.   Satisfactory   Hardly satisf.   Not at all satisf.

14) On a scale of 1–10, rate the following electricity-producing technologies, depending on how environmentally–friendly they are: *(1 for the least and 10 for the most environmentally–friendly; you can use the same ranking for more than one answer)*

Lignite combustion   Coal combustion   Oil combustion
Natural gas combustion   Hydroelectric energy   Wind energy
Solar energy   Nuclear fuel   Biofuels
Geothermal energy   Other:

15) On a scale of 1–10, rate the advantages stemming from the use of renewable energy sources: (1 *for the least important and* 10 *for the most important contribution; you can use the same ranking for more than one answer*)

Reduction of CO_2 emissions.
Improved energy supply and energy security on a national level.
Low operating cost.
Ability to cover energy requirements at the production area, resulting in fewer losses during transport.
New employment opportunities.
Other:

16) On a scale of 1—10, rate the disadvantages stemming from the use of renewable energy sources: (1 *for the least important and* 10 *for the most important contribution; you can use the same ranking for more than one answer*)

Uncontrolled rate at which the energy is provided and its availability, when required.
High manufacturing cost.
Downgrading of installation areas and reduction in land value.
Lack of transparency regarding installation licences.
Need for specialized staff.
Other:

17) On a scale of 1–10, rate the main types of renewable energy sources you would like to see developed on your island: (1 *for the least important and* 10 *for the most important contribution; you can use the same ranking for more than one answer*)

Hydroelectric energy   Biofuels   Solar energy
Geothermal energy   Wind Energy   OTHER:

18) How well-informed are you about the RES systems that can be used in houses?

Very well   Well   Quite well   A little   Not at all

19) The installation of electricity production systems from RES in buildings is quite costly, but can save money. In the case of a state subsidy, what percentage would motivate you to install such a system?

0–20%   21–40%   41–60%   61–80%   81–100%

20) Do you agree with the installation of wind turbines in the northern part of the island?

I totally agree   I agree   I disagree   I totally disagree

Would you agree with the installation of wind turbines in an area that was visible from where you live?

I totally agree   I agree   I disagree   I totally disagree

Would you agree with the installation of wind turbines in the sea?

I totally agree   I agree   I disagree   I totally disagree

21) Do you follow public events taking place in your municipality (e.g. do you take part or attend municipal councils for information etc.)?

Yes   No

22) Gender: Male   Female

23) Age: 18–30   31–40   41–50 >50

24) Education: Did not complete primary school   Primary school   Lower secondary school
Technical school   Upper secondary school
Technological educational institute   University

25) What is your family status?

Single   Married   Divorced (separated)   Widow/er

No of children:

26) What is your main profession?

Private employee   Farmer   Workman
Private employee   Student—pupil   Housewife
Self-employed   Pensioner   Unemployed

27) If you so wish, could you please sincerely state your gross annual income?

Less than 5000 €   5001–10,000 €   10,001–20,000 €
20,001–30,000 €   Over 30,000 €   No answer

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